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(54) Title of the invention: Disc Master Exposure Device and Method

(57) Abstract

Purpose: In order to provide a disc master exposure device that can expose fine pits and narrow trenches with high accuracy and has a development function,

Configuration: A disc master exposure device 100 condenses and irradiates laser light on a disc master 19 where a photoresist film 20 has been coated to expose the disc master 19 in a desired pattern. A nozzle 210 fills water into a gap between a condensing lens 17 and the disc master 19 during the exposure. As the numerical aperture of the condensing lens 17 increases, it functions as an immersion lens. By piping the nozzle into a water reservoir and a developing liquid reservoir and providing a valve for switching a supply liquid between water and the developing liquid, the disc master exposure device may function as a developing device.

S-POLARIZATION
LASER LIGHT SOURCE
P-POLARIZATION
DISC MASTER

Scope of Patent Claims

Claim 1

A disc master exposure device that exposes a photoresist in a desired pattern by condensing and irradiating laser light onto a recording medium production disc master where a photoresist is coated, the disc master exposure device comprising:

an optical element for condensing the laser light to a surface of the disc master; and

a means for interposing a liquid into an optical path between the optical element and a surface of the disc master.

Claim 2

The disc master exposure device according to claim 1, wherein the optical element functions as an immersion lens.

Claim 3

The disc master exposure device according to claim 1 or 2, wherein the means for interposing the liquid includes a nozzle for discharging the liquid into the disc master and a liquid supply device for supplying the nozzle with the liquid.

Claim 4

The disc master exposure device according to any one of claims 1 to 3, further comprising a means for supplying a developing liquid onto the disc master.

Claim 5

The disc master exposure device according to claim 4, wherein the means for supplying the developing liquid onto the disc master includes a nozzle for discharging the liquid or the developing liquid onto the disc master, a supply device for supplying the nozzle with the liquid or the developing liquid, and a switching device for switching the supply to the nozzle between the liquid and the developing liquid.

Claim 6

The disc master exposure device according to claim 5, further comprising an inspection device for inspecting the disc master that has been exposed and developed.

Claim 7

The disc master exposure device according to claim 6, wherein the inspection device is an optical head including the optical element of the disc master exposure device.

Claim 8

The disc master exposure device according to any one of claims 1 to 7, wherein the liquid is water.

Claim 9

A disc master exposure method for exposing a photoresist in a desired pattern by condensing and irradiating laser light onto a recording medium production disc

master where a photoresist has been coated, wherein the disc master is exposed while a liquid is interposed between the disc mater and an optical element for condensing the laser light.

Detailed Description of the Invention

[0001]

Industrial Field of Utilization

The present invention relates to a disc master exposure device for manufacturing a disc master of a substrate for a recording medium such as an optical disc, and more particularly, to a disc master exposure device and a disc master exposure method capable of improving an exposure resolution when the disc master where the photoresist has been coated is exposed.

[0002]

Prior Art

A substrate for a compact disc or an optical magnetic disc is manufactured by forming a pattern of grooves or pre-embossed pits corresponding to a pre-format signal through an exposure and developing processes on a disc master, manufacturing a stamper by duplicating the resulting disc master, and then performing injection molding of a plastic material or the like using an injection molding machine with the stamper installed. A disc master exposure device is used to form a pattern of grooves or pre-embossed pits on the disc master. The disc master exposure device exposes the photoresist in a predetermined pattern by turning on or off laser light irradiated onto the disc master surface in response to the pre-format signal while rotating the glass disc master where a photoresist is typically coated. The exposed disc master is removed from the disc master exposure device and then installed in a turntable of a developing device to perform development by supplying an alkali liquid onto the rotating disc master surface from the upper side. As the development is finished, whether or not the dimensions of the trenches or pits formed in the disc master are correct is inspected using an inspection device having an optical head. As a result, a disc master for forming the stamper is manufactured.

[0003]

As the disc master exposure device described above, for example, "The Japanese Journal of the Institute of Image Information and Television Engineers," Vol 37, No. 6, 475-490 pages (1983) discloses a laser cutting machine for a VHD/AHD type video disc capable of reducing the spot size of the laser light to approximately 0.5 μm on the disc master using a laser light wavelength λ of 457.98 nm and an optical head having a lens numerical aperture (NA) of 0.93. It was reported that an embossed pit having a minimum size of 0.25 μm can be formed using this cutting machine. In addition, this cutting machine uses a focusing servo system which adopts

a He-Ne laser as a subsidiary beam in order to match the laser spot with the disc master.

[0004]

Japanese Unexamined Patent Application Publication No. H06-187668 discloses a method of manufacturing an optical disc master capable of reducing crosstalk from neighboring tracks even when it is recorded with a narrow track pitch and a high density, and a laser cutting machine having nearly the same configuration as that disclosed in the aforementioned document is used in the disc master exposure.

[0005]

Problems to Be Solved by the Invention

As the information amount remarkably increases due to the recent popularity of multimedia, information recording media such as an optical disc are demanded to provide increasingly high density and high capacity. In response to this demand, a disc master exposure device is also demanded to more finely expose a pattern of grooves or embossed pits recorded on the optical disc or the like. It is considered that the numerical aperture (NA) of the lens for condensing the laser light into the disc master needs to increase, and the wavelength of the laser light needs to decrease in order to expose such a fine pattern. However, since there are limitations in the NA of the lens and the shortening of the wavelength of the laser light, it is difficult to significantly improve the exposure resolution.

[0006]

As described above, since the exposure and developing processes are separately performed using the disc master exposure device and the developing device, respectively, device costs increase, and space for installing the devices is also demanded. Furthermore, the processes until the stamper is manufactured are complicated.

[0007]

An object of the present invention is to provide a disc master exposure device capable of implementing a narrow trench corresponding to a fine information pit and a narrow track pitch.

[0008]

Another object of the present invention is to provide a disc master exposure device having a development function as well as an exposure function, whereby the exposure resolution is improved.

[0009]

Still another object of the present invention is to provide a disc master exposure method capable of implementing a narrow trench corresponding to a fine information pit and a narrow track pitch.

Means to Solve Problems

According to a first aspect of the present invention, there is provided a disc master exposure device that exposes a photoresist in a desired pattern by condensing and irradiating laser light onto a recording medium production disc master where photoresist is coated, the disc master exposure device including: an optical element for condensing the laser light to a surface of the disc master; and a means for interposing a liquid into an optical path between the optical element and a surface of the disc master.

[0010]

A principle of the disc master exposure device according to the present invention will be described with reference to FIG. 6. FIG. 6 is an enlarged conceptual diagram illustrating the vicinity of a disc master 19 exposed by the optical head of the disc master exposure device according to the present invention. Laser light 4 irradiated from the laser light source (not shown) of the disc master exposure device is condensed into the surface of a photoresist film 20 coated on the disc master using a condensing lens 17 through a relay lens 15. The disc master exposure device according to the present invention has a nozzle 210 for supplying a liquid 200 to the surface of the disc master as shown in FIG. 6. During the exposure operation, the gap between the condensing lens 17 and the photoresist film 20 of the disc master is filled with a liquid 200 supplied from a nozzle 210. Here, a minimum interval r between two points identifiable by the condensing lens 17 is generally represented by the following equation (1).

[0011]

Equation 1

$$r = \lambda/NA = \lambda/(n \bullet \sin\alpha) \quad \ldots. (1)$$

In this equation, λ denotes the wavelength of the laser light 4 incident to the condensing lens 17, and NA denotes a numerical aperture of the condensing lens 17, n denotes a refractive index of a medium in the object point side (the disc master side) of the condensing lens 17, and α denotes a half of a maximum opening of the light beams irradiated from the condensing lens 17, i.e., an opening half-angle. It can be said that, as the minimum interval r between two points identifiable by the condensing lens 17 decreases, the exposure resolution of the disc master exposure device increases. It is recognized from the aforementioned equation (1) that the numerical aperture NA may increase in order to reduce the interval r when the wavelength λ of the laser light is constant. Since the numerical aperture NA is defined by $NA=n \bullet \sin\alpha$ as described in the equation (1), the refractive index n and the opening half-angle α may increase in order to increase the NA. According to the present invention, since a liquid 200 ($n > 1$) is filled between the surface of the disc master 20 and the condensing lens 17, it is possible to increase the NA in comparison with the condensing lens of a conventional disc master exposure device when the air ($n=1$) is

interposed between the surface of the disc master and the condensing lens. In other words, in the disc master exposure device according to the present invention, the condensing lens 17 can function as an immersion lens. The liquid 200 preferably has a large refractive index in order to increase the NA. However, when the interval between the surface of the disc master 20 and the condensing lens 17 is finely adjusted from the viewpoint of prevention of aberration of the lens 17, a liquid having a refractive index close to that of the condensing lens 17 such as a cedarwood oil is preferably used. However, since the liquid 200 makes contact with the photoresist film 20 of the disc master, water is very suitable because a post process can be readily performed without corroding the photoresist.

[0012]

The disc master exposure device according to the present invention may further include a means for supplying the developing liquid onto the disc master. By installing the developing liquid supply means in the disc master exposure device, since the developing device that has been used in the process subsequent to the exposure becomes dispensable, it is possible to simplify the exposure and developing processes.

[0013]

The means for supplying the developing liquid onto the disc master may include: a nozzle for discharging a developing liquid or a liquid interposed between the optical element and the disc master onto the disc master; a supply device for supplying the nozzle with the liquid or the developing liquid; and a switching device for switching the supply to the nozzle between the liquid and the developing liquid. In a specific example of the disc master exposure device according to the present invention, since the nozzle for discharging the liquid onto the disc master and the supply device for supplying the liquid to the nozzle are used to interpose a liquid between the condensing lens and the disc master, the nozzle and the liquid supply device can also be used to supply the developing liquid by installing a switching device such as an electromagnetic valve capable of switching the supply liquid between the developing liquid and the exposure liquid. Therefore, the developing function can be provided in the disc master exposure device using a simpler structure.

[0014]

The disc master exposure device according to the present invention may further include an inspection device for inspecting the width or the depth of a pit or a trench in the disc master where the exposure and the development have been performed. As a result, according to the disc master exposure device, since exposure, development, and inspection processes can be performed in a single device, device costs can be reduced, and the processes performed to manufacture the stamper can be simplified. Since the conventional inspection device has an optical head to inspect the

width of the pit or the trench that has been developed and exposed by scanning an inspection light from the optical head, the optical head including the condensing lens of the disc master exposure device can be used as an optical head for inspection. Therefore, it is possible to simplify and miniaturize the device.

[0015]

According to a second aspect of the present invention, there is provided a disc master exposure method for exposing the photoresist in a desired pattern by condensing and irradiating laser light onto a recording medium production disc master where the photoresist has been coated, wherein the disc master is exposed while a liquid is interposed between the optical element for condensing the laser light and the disc master.

[0016]

In the disc master exposure method according to the present invention, since the disc master is exposed while a liquid is interposed between the disc master and the optical element for condensing the laser light, it is possible to improve the exposure resolution of the optical head by using the optical element as an immersion lens. In addition, dust or the like adhered on the disc master during the exposure can be removed by having the liquid flow.

[0017]

Embodiments

Hereinafter, embodiments and examples of the disc master exposure device using a solid-state immersion lens according to the present invention will be described with reference to the accompanying drawings.

[0018]

First Embodiment

A first embodiment of the disc master exposure device according to the present invention will be described with reference to FIG. 1. FIG. 1 illustrates a schematic configuration of a disc master exposure device 100. The disc master exposure device 100 generally includes a laser light source 1 that emits laser light for exposure, an acousto-optics (AO) modulator 7 and an acousto-optics (AO) deflector 9 that adjust an irradiation timing and an irradiation location, respectively, to a disc master 19, an exposure optical head 27, a turntable 21 for rotating the disc master 19, a water/developing liquid supply device 220 and a nozzle 210 used to discharge water onto the disc master 19, a display 26 and a pickup tube 24 for observing the irradiated spots, and various optical elements such as a beam splitter 3, a mirror 11, a half-mirror 13, and a lens 6 for adjusting an optical path.

[0019]

The laser light beam 2 output from the laser light source 1 can be divided into a first light beam 4 and a second light beam 5 by the beam splitter 3. The first light

beam 4 is incident to the AO modulator 7 interposed between a pair of lenses 6 and modulated to pulse light corresponding to the timing of the signal to be recorded. The pulse light modulated at the AO modulator 7 is reflected at the mirror 8 and incident to the AO deflector 9 so that it is deflected to irradiate in a predetermined radial direction of the disc master 19. Then, the deflected light is incident to the optical head 27 through the polarization mirror 10 and the mirror 11. The relay lens 15 and the condensing lens 17 which will be described below are installed in the optical head 27, and the laser light is condensed into a predetermined location on the surface of the disc master 19 by those lenses. The photoresist 20 sensitive to the incident light is previously coated on the disc master 19. Meanwhile, the second light beam 5 is incident to the EO modulator 12. The irradiation timing and the exposure light quantity may be modulated by the EO modulator 12 instead of the AO modulator 7. The light passing through the EO modulator 12 is reflected at the half-mirror 13 and transmitted through the $\lambda/2$ phase plate 14. Then, the light arrives at the optical head 27 through the polarization mirror 10 and the mirror 11.

[0020]

The nozzle 210 is arranged in the upper side of the turntable 21 near the center of the disc master 19 and discharges water 200 to the disc master 19. As the disc master 19 is rotated by the turntable 21, water 200 is spread onto the outer periphery of the disc master 19 by virtue of centrifugal force and forms a water film which covers the photoresist film 20 of the disc master. The water 200 flowing toward the outer periphery of the disc master 19 fills the gap between the surface of the photoresist 20 of the disc master and the condensing lens 17. Therefore, the condensing lens 17 functions as an immersion lens.

[0021]

The light irradiated to the photoresist film 20 on the disc master 19 from the optical head 27 forms a spot smaller than the theoretical minimum spot diameter within the air based on the equation (1) and the principle of the immersion lens and is sensed by the photoresist film 20. Therefore, the exposure resolution is improved in comparison with that of the conventional disc master exposure device, and it is possible to expose a pattern of the guide trenches and the finer pits with high accuracy. Details of the structure of the optical head 27 will be described below.

[0022]

The light reflected at the surface of the photoresist film 20 of the disc master 19 becomes paralleled light when it transmits through the condensing lens 17 and the relay lens 15, and it is condensed into the pickup tube 24 by the lens 22 through the mirror 11, the polarization mirror 10, and the half-mirror 13. By observing the spot images 26a and 26b displayed on the display 26 of the pickup tube 24, it is possible to identify the spot shape formed by the condensing lens 17.

[0023]

Operations of the laser light source 1, the AO modulator 7, the EO modulator 12, the turntable 21, and the like are collectively managed by the control unit (not shown, refer to FIGS. 3 and 4). The pre-format signal is input to the control unit, and the light-emitting period or the like of the AO modulator 7 or the like is adjusted depending thereon.

[0024]

Next, details of the structure of the optical head 27 of the disc master exposure device 100 will be described with reference to FIGS. 2 and 3. FIG. 2 is a perspective diagram illustrating the optical head 27 supporting the condensing lens 17 through an elastic member 18 as seen from the lower side. FIG. 3 is an enlarged cross-sectional diagram illustrating the optical head 27. In FIG. 3, in order to make it easy to understand the structure of the optical head 27, the water 200 discharged from the nozzle 210 is omitted.

[0025]

As shown in FIG. 2, the optical head 27 includes a condensing lens 17, a condensing lens holder 16a for holding the condensing lens 17, and an optical head base portion 28. The condensing lens holder 16a is supported by four support members 29 fixed in the bottom surface of the base portion 28 and an elastic member 18a such as a plate spring connected thereto. By virtue of such a support structure, the condensing lens holder 16a is restricted in a direction (X and Y directions in the drawing) parallel to the plane of the disc master and movable in an optical axis direction (the Z direction in the drawing) of the condensing lens 17.

[0026]

As shown in FIG. 3, the condensing lens holder 16a has a relay lens holder 32 that supports the relay lens 15 through the piezoelectric element 33 in the upper side thereof. Here, the piezoelectric element 33 minutely adjusts the position of the focal point of the relay lens 15 by modifying the optical axis direction location of the relay lens 15 with respect to the condensing lens 17.

[0027]

The relay lens holder 32 is connected to the support member 29 of the base portion 28 through the elastic member 18b. A bobbin 34e included in the voice coil type actuator 140 is fixed on the relay lens holder 32. Other components of the actuator 140 such as a coil 34f, a permanent magnet 35b, and yokes 36c and 36d are installed in the base portion 28. As a result, as the actuator 140 is driven, the condensing lens 17 and the relay lens 15 move in the optical axis direction (in the vertical direction of the drawing) with respect to the base portion 28. The actuator 140 is driven by the control unit 88 based on the result of observation of the spot images 26a and 26b using the display 26 of the pickup tube 24. As a result, the gap

between the end section of the condensing lens 17 and the surface of the disc master 19 is adjusted to an appropriate value. The gap between the end section of the condensing lens 17 and the surface of the disc master 19 is generally adjusted by several micrometers to several tens of micrometers depending on the focal length of the condensing lens 17.

[0028]

The condensing lens 17 is a semispherical lens formed by cutting out a part of the sphere. The cutaway section of the lens 17, i.e., the output surface 17a of the lens 17 is preferably fabricated in a curved surface having a convex shape in order not to trap vapor included in water on the output surface. While the shape of the lens and the location of the cutaway section of the lens are not particularly limited, the condensing lens 17 may be fabricated as an aplanatic lens. Materials of the condensing lens 17 may include, but not particularly limited to, C, SiC, Si_3N_4, ZrO_2, Ta_2O_5, ZnS, TiO_2, high refractive index glass, general optical glass, crystal, or the like.

[0029]

Next, details of the structure of the water/developing liquid supply device 220 of FIG. 1 will be described with reference to FIG. 4. The water/developing liquid supply device 220 generally includes reservoirs 82 and 84 for generally storing the developing liquid (alkali liquid) and water, respectively, a nitrogen pump 92 for internally pressing the reservoirs, pipes 80, 80a, 80b for supplying the water/developing liquid to the nozzle 210 from the reservoirs 82 and 84, a control unit 88, or the like. The nozzle 210 for discharging the water/developing liquid is connected to the pipe 80 and intermediately divided into a pipe 80a connected to the developing liquid reservoir 82 and a pipe 80b connected to the water reservoir 84. Electromagnetic valves 86a and 86b are installed in the pipes 80a and 80b, respectively, and their open/close state is controlled by the control unit 88. A flow rate control valve 90 is installed in the middle of the pipe 80 so that the flow rate of the liquid discharged from the nozzle 210 is controlled by the control unit 88. The developing liquid reservoir 82 and the water reservoir 84 are supplied with high-pressure nitrogen from the nitrogen pump 92 so that the developing liquid and the water flow out to the pipes 80a and 80b from the reservoirs 82 and 84 by internally pressing the reservoirs. The nitrogen pump 92 is also controlled by the control unit 88. In addition, the control unit 88 is integrated with the control unit that collectively manages the exposure operation of the disc master exposure device of FIG. 1.

[0030]

Operations of the developing liquid/water supply device 220 of FIG. 4 will be described hereinafter. During the exposure in the disc master exposure device, the control unit 88 performs control such that the electromagnetic valve 86b of the water

reservoir 84 is opened to supply water within the water reservoir 84 to the pipe 80. The control unit 88 also controls the flow rate control valve 90 to adjust the flow rate of the water flowing through the pipe 80 to discharge a suitable amount of water from the nozzle 210. As a result, during the exposure, the gap between the condensing lens 17 and the photoresist 20 on the surface of the disc master is filled with water so that the condensing lens 17 functions as an immersion lens. In addition, since dust or the like adhered on the photoresist film 20 during or before the exposure is removed by flow of the water from the nozzle, it is possible to prevent degradation of the exposure accuracy caused by adhered particles such as dust. It is necessary to set the amount of water discharged from the nozzle 210 so as to ensure the gap between the condensing lens 17 and the photoresist 20 on surface of the disc master is always filled with water. However, it is preferable that the gap between the condensing lens 17 and the photoresist 20 on the surface of the disc master is not changed by the flow of water on the disc master. The discharge direction of the nozzle 210 may be set to a horizontal direction in order to stabilize the flow of water on the disc master. In addition, the end of the bottom surface of the condensing lens holder 16a may have a curved surface in order to reduce water resistance in the condensing lens holder 16a.

[0031]

As the exposure of the disc master 20 is terminated, the control unit 88 performs control such that the electromagnetic valve 86b is closed, and the electromagnetic valve 86a in the developing liquid reservoir 82 side is opened to switch the liquid discharged from the nozzle 210 from water to the developing liquid. The flow rate control valve 90 adjusts the flow rate of the developing liquid under control of the control unit 88 to discharge the developing liquid from the nozzle 210 at a suitable flow rate. As a result, the disc master 20 where the exposure process has been performed is developed.

[0032]

In the device 220 shown in FIG. 4, water and the developing liquid can be supplied using the same nozzle 210 by switching the electromagnetic valve 86a and 86b. Therefore, it is possible to perform the developing process without moving the light-sensed disc master after the exposure.

[0033]

Furthermore, the optical head 27, the pickup tube 24, and the display 26 shown in FIG. 1 can also be used as an inspection device for inspecting the width or the depth of pits and trenches formed on the disc master after the exposure and developing processes are terminated. By constructing the disc master exposure device as described above, it is possible to use the conventional disc master exposure device as a single multi-function device capable of performing the exposure, the development, and the inspection.

[0034]

Second Embodiment

A second embodiment of the disc master exposure device according to the present invention will be described with reference to FIG. 5. FIG. 5 is a cross-sectional diagram illustrating a modified example of the optical head 27 of the disc master exposure device of FIG. 3. The optical head of FIG. 5 has the same structure as that of the optical head of the disc master exposure device 100 of the first embodiment except that the structure of the condensing lens holder 16b that supports the condensing lens 17 is different from that of the condensing lens holder 16a of FIG. 3. Therefore, like reference numerals denote like elements as in the disc master exposure device 100 of the first embodiment, and detailed descriptions thereof will be omitted. For convenience of understanding the structure of the condensing lens holder 16b, water discharged from the nozzle 210 is not shown in FIG. 5.

[0035]

The condensing lens holder 16b supports the condensing lens 17 in the center thereof, and the bottom portion of the holder forms a conical face such that the interval from the disc master 19 outwardly increases. Inside the condensing lens holder 16b, cavities (optical paths) 16f and 16g communicating to the condensing lens 17 from the outer side are symmetrically formed by interposing an optical axis of the condensing lens 17 therebetween. An optical fiber 40 is installed in the opening (optical incidence hole) of one of the optical paths 16f, and a lens position detector 41 having a slit 41a and a detection unit 41b is installed in the opening (optical exit hole) of the other optical path 16g. The detection unit 41b of the lens position detector 41 is connected to the control unit 88 for controlling the aforementioned voice coil motor 140. That is, in the disc master exposure device of the first embodiment, the voice coil motor 140 is controlled based on the result of observation using the display 26. However, in this embodiment, the voice coil motor 140 is controlled based on the detection signal from the lens position detector 41.

[0036]

The light output from the optical fiber 40 is incident to the condensing lens 17 through the cavity (optical path) 16f, reflected by the disc master 19, and then incident to the lens position detector 41 through the condensing lens 17 and the cavity (optical path) 16g. The lens position detector 41 is divided into the detection units 41a and 41b and designed such that the center of the reflection light from the disc master is arranged between the detection units 41a and 41b of the lens position detector 41 when the interval between the end section 17c of the condensing lens 17 and the surface of the disc master 20 is within a predetermined suitable value. That is, in this case, the light amount of the reflection light becomes equal in the detection units 41a and 41b. Therefore, during the exposure, i.e., when water is discharged from the

nozzle 210 and flows on the photoresist 20 on the surface of the disc master, if the interval between the end section 17c of the condensing lens 17 and the photoresist 20 of the disc master is not within an appropriate interval, the balance of the reflection light detection output from the detection units 41a and 41b is corrupted. Accordingly, the control unit performs control such that the interval between the condensing lens 17 and the disc master 19 can be modified to an appropriate value by driving the voice coil type actuator 140 in response. When a liquid such as water is filled between the surface of the photoresist 20 and the condensing lens 17, if the refractive indices of the photoresist and the liquid are close to each other, the intensity of the light output from the optical fiber 40 and reflected at the surface of the photoresist 20 is reduced, and the light amount detected by the position light detection unit is reduced so that the servo may become unstable. In this case, the light amount may be increased by forming a reflection film such as aluminum between the photoresist and the disc master.

[0037]

Since the disc master exposure device of FIG. 5 has a lens position detector 41, the interval between the condensing lens 17 and the disc master is automatically adjusted by the control unit 88 so that it can be always maintained within an appropriate value. Therefore, even when a shaking is generated in a vertical direction in the condensing lens holder 16b due to variation in the flow rate of the water supplied on the surface of the disc master during the exposure, it is possible to alleviate the shaking and maintain the interval between the condensing lens 17 and the disc master within an appropriate value.

[0038]

Hereinbefore, while embodiments of the present invention have been described, the present invention may include various changes and modifications without departing the scope of the attached claims. While, in the aforementioned embodiments, the nozzle is arranged such that the water/developing liquid can be discharged to the vicinity of the center of the disc master, the position of the nozzle may be arranged in any positions if the gap between the disc master and the condensing lens can be filled with water by the rotation of the disc master. For example, the nozzle may be arranged in the same position as that of the condensing lens in the radial direction of the disc master in front of the rotation direction of the disc master. In addition, the discharge direction of the liquid from the nozzle may be adjusted in an arbitrary direction by changing the direction of the nozzle.

[0039]

While water is discharged onto the disc master using the nozzle in the aforementioned embodiments, water may be filled in the gap between the disc master and the condensing lens by forming a casing by providing a wall surface along the

outer periphery of the disc master and using the disc master as the bottom and accumulating a certain amount of water within the casing. In this way, it is possible to reduce the amount of water discharged from the nozzle or suppress shaking of the condensing lens holder caused by the flow of water by filling the casing with water from the nozzle only before the exposure. In addition, only the casing structure described above may be employed by omitting the nozzle. That is, any method may be used if it can interpose water in the gap between the disc master and the condensing lens.

[0040]

The aforementioned disc master exposure device may include an evacuation mechanism for evacuating the optical head from the disc master during the developing process or an optical head cover for preventing the developing liquid from being adhered to the optical head. By providing the evacuation mechanism or the optical head cover described above, it is possible to protect the optical head from the developing liquid which is an alkali liquid and prevent corrosion of the lens and the lens holder.

[0041]

The disc master exposure device according to present invention may be used to manufacture an embossed pit type magnetic recording medium used in a hard disc or the like in addition to an optical recording medium dedicated to reproduction, such as a compact disc, a CD-ROM, or a digital video disc, a recordable recording medium such as a CD-R, a rewritable recording medium such as an optical magnetic disc.

[0042]

Effects of the Invention

In the disc master exposure device according to the present invention, since the condensing lens can function as an immersion lens by interposing a liquid between the condensing lens and the disc master, it is possible to further improve the exposure resolution. Accordingly, it is possible to manufacture a disc master for a high density recording medium in which an extremely fine pit, e.g., a pit having a diameter equal to or smaller than 0.2 μm is formed.

[0043]

In addition, since the disc master exposure device according to the present invention has the developing liquid supply means, the developing device used in the processes after the exposure in the related art becomes dispensable, and it is possible to simplify the exposure and developing processes. Particularly, since the developing liquid supply means includes the nozzle for discharging the developing liquid or the liquid interposed between the optical element and the disc master onto the disc master, the supply means for supplying the liquid or the developing liquid to the nozzle, and the switching device for switching the supply to the nozzle between the

liquid or the developing liquid so that the developing liquid and the exposure liquid can be discharged form the nozzle by switching therebetween, it is possible to provide the developing function to the disc master exposure device using a simpler structure.

[0044]

The disc master exposure device according to the present invention includes an inspection device for inspecting the width or the depth of pits or trenches of the disc master where the exposure and developing processes have been performed. Therefore, in the disc master exposure device, since the exposure, developing, and inspection processes can be performed using a single device, it is possible to reduce device costs and simplify the process performed to manufacture the stamper.

[0045]

In the disc master exposure method according to the present invention, since exposure of the disc master is performed while a liquid is interposed between the optical element for condensing the laser light and the disc master, it is possible to use the optical element as an immersion lens and remove dust or the like adhered on the disc master during the exposure. Therefore, it is possible to improve the exposure accuracy and the exposure resolution of the optical head.

Brief Description of the Drawings

FIG. 1

FIG. 1 is a conceptual diagram illustrating an entire configuration of a disc master exposure device according to the present invention.

FIG. 2

FIG. 2 is a perspective diagram illustrating a first embodiment of an optical head of the disc master exposure device of FIG. 1 as seen from the bottom according to the present invention.

FIG. 3

FIG. 3 is a cross-sectional diagram illustrating a first embodiment of an optical head of the disc master exposure device of FIG. 1 according to the present invention.

FIG. 4

FIG. 4 is a conceptual diagram illustrating structures of a nozzle and a water/developing liquid supply device of the disc master exposure device according to first and second embodiments of the present invention.

FIG. 5

FIG. 5 is a cross-sectional diagram illustrating an optical head of the disc master exposure device according to the second embodiment of the present invention.

FIG. 6

FIG. 6 illustrates that a condensing lens of the disc master exposure device of the present invention functions as an immersion lens.

Description of Symbols

3 BEAM SPLITTER
7 AO MODULATOR
9 AO DEFLECTOR
16a and 16b CONDENSING LENS HOLDER
17 CONDENSING LENS
18 ELASTIC MEMBER
20 PHOTORESIST
27 OPTICAL HEAD
28 OPTICAL HEAD BASE PORTION
29 SUPPORT MEMBER
82 DEVELOPING LIQUID RESERVOIR
84 WATER RESERVOIR
92 NITROGEN PUMP
100 DISC MASTER EXPOSURE DEVICE
130 VOICE COIL TYPE ACTUATOR
200 WATER
210 WATER/DEVELOPING LIQUID DISCHARGE NOZZLE

FIG. 1

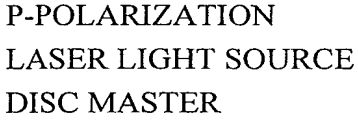

FIG. 3

FIG. 4

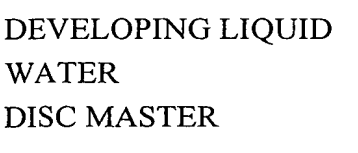

FIG. 5

FIG. 6
DISC MASTER